

DFCM Radon Investigation and Abatement Program

Utah State Fish Hatcheries

**Air Quality Consulting, LLC and
R & R Environmental, Inc.**

The Issue

- ▶ Radon gas dissolves quite readily into water. Spring water often has high concentrations of Radon, which is liberated from the water during agitation. Hatcheries often need to agitate massive quantities of water to remove harmful substances (like carbon dioxide or nitrogen) or to add oxygen. This places Hatchery workers in close proximity to potentially high levels of Radon.





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Hatchery Radon History

- Some Radon gas sampling had been conducted in years past, even to the extent that the Division had purchased a real-time Radon monitor which had been passed around to some of the sites. Exposure information was not widely disseminated, which caused some ill feelings toward management....What brought this up again...

Education

- ▶ The first step was to educate the employees about Radon and do short-term testing of the facilities.

RADON BACKGROUND

- ▶ Element (Rn); Noble (inert) Gas
- ▶ Colorless (invisible), Odorless, Tasteless
- ▶ Naturally Occurring (soils, granite and phosphate rocks)
- ▶ Radionuclide, Emits* Ionizing Radiation (damaging to DNA)

Radon is an Element

- ▶ It cannot be neutralized; it must be pushed elsewhere.
- ▶ Current technology is to maintain negative pressure below slab and vent to the roof (to the neighbors, if you're lucky)

RADON BACKGROUND, con't.

- ▶ Nine Times Heavier Than Air (heaviest known gas)
- ▶ Little Practical Use except “seeds” (small, sealed glass tubes) also called “needles”
- ▶ Does not mix well with Chemicals
- ▶ Half-life is 3.8 Days (Rn222)
- ▶ Dissolves into water

RADIATION BACKGROUND

▶ Alpha (α) Particles

- Heaviest; least penetrating; inhalation hazard only due to impact on delicate lung tissue

▶ Beta (β) Particles

- Moderately penetrating; inhalation/external hazard

▶ Gamma (γ) Rays

a.k.a.: “pure energy”; Extremely penetrating; deep organ damage potential; inhalation/external hazard; sometimes called “Penetrating Radiation”

Radon Decay Chain

- ▶ Uranium 238 (92 p, 146 n)
HL:4.5b yrs >@
- ▶ Thorium 234 (90 p, 144 n)
HL:24.5d >B,G
- ▶ Proactinium 234 (91 p, 143 n) HL:269k yrs >B,G
- ▶ Thorium 230 (90 p, 140 n)
HL:83k yrs >@,G
- ▶ Radium 226 (88 p, 138 n)
HL:1,590 yrs >@,G
- ▶ Radon >>>>
- ▶ Radon 222 HL:3.825 da
>4@, 3B, 2G*
 - In Lung (w/in 52 min.):
- ▶ Polonium 218 HL:3.08 m >@
- ▶ Lead 214 HL:26.8 m >B,G
- ▶ Bismuth 214 HL:19.7 m >@/
B,G
- ▶ (Polonium 214 HL:150ms
>@)
- ▶ Thallium 210 HL:1.32 m >B
- ▶ Lead 210 HL:22 yrs >B,G
- ▶ Bismuth 210 HL:5da >B
- ▶ Polonium 210 HL:138da >@,G
- ▶ Lead 206 HL: n/a: (STABLE)

Hazardous materials enter the body via:

Inhalation*

Absorption

Ingestion

Injection

*Radon is an inhalation hazard

Cancer Risk Summary

- ▶ Lung tissue is the most delicate tissue in the body, often only one cell thick
- ▶ In less than 52 minutes, the Radon decay chain gives off 4 alpha particles, 3 beta particles and 2 gamma rays; the result is a radioactive isotope of lead (Lead 210, has a half-life of 22 years)

European Health Dichotomy

- ▶ Radon Therapy is acceptable choice for rheumatism by prescription (Gasteiner Heilstollen, Austria: 4,500 pCi; Radium Palace, Czech Republic; Erze, Badcastien, Germany) with medical professionals onsite
- ▶ Near Boulder and Basin, Montana there are 4 mines open for “therapy” 1,600 pCi (Free Enterprise Radon Health Mine, Merry Widow Mine, etc.)

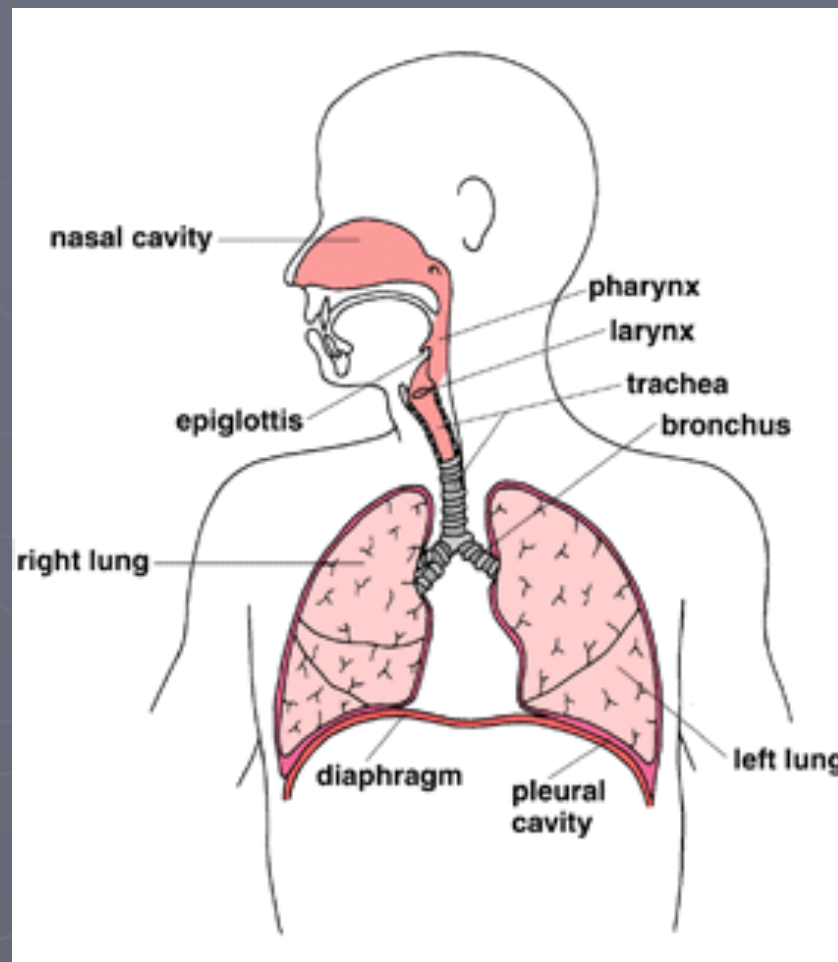
Radon: Why The Concern

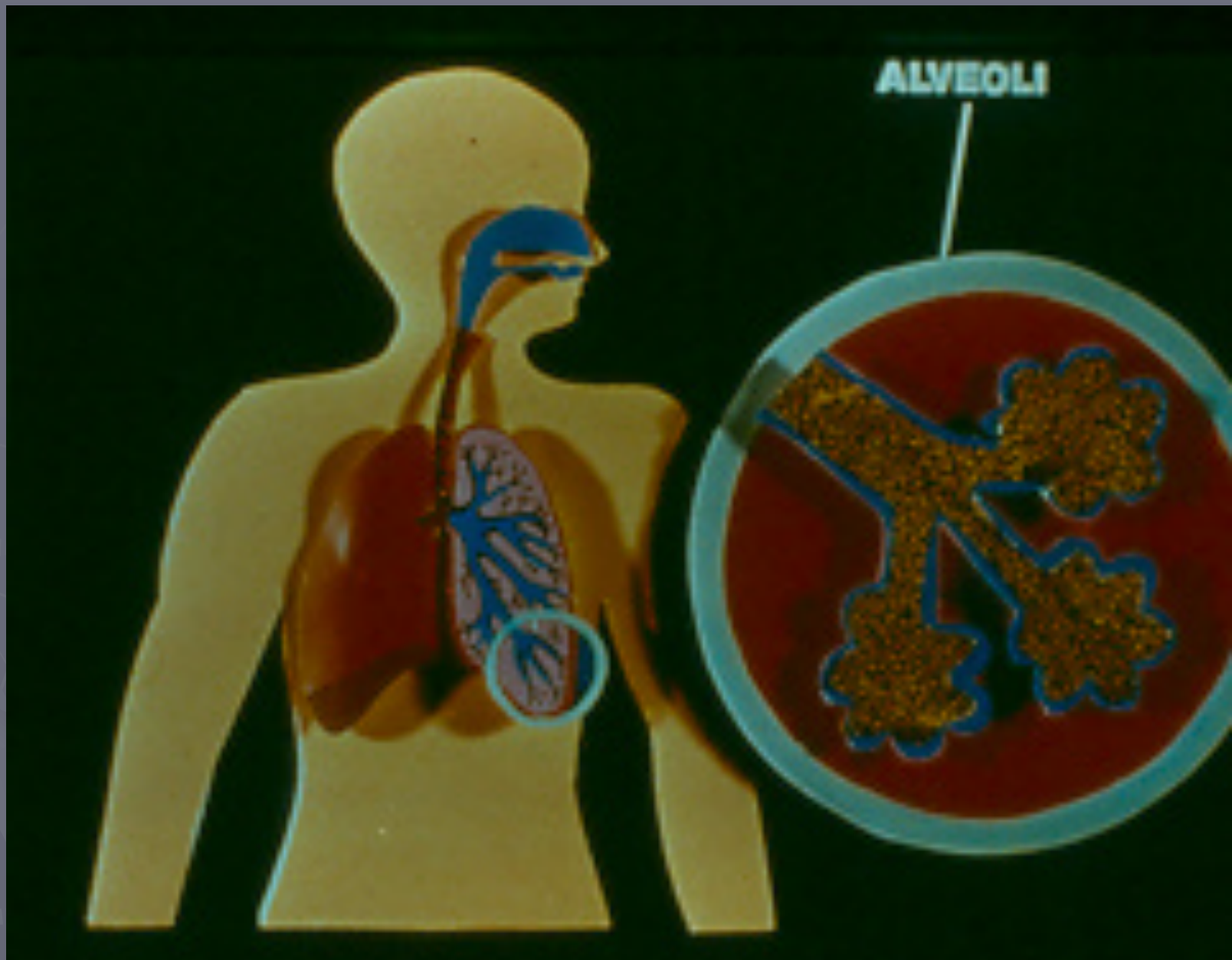
- ▶ Suspected: Cause of 10% of all lung cancers (more than any other passive environmental concern)
- ▶ Is a “Known Human Carcinogen”
- ▶ Smokers especially vulnerable (radon clings to dust/smoke particles)
- ▶ NAS: 20,000 deaths each year
- ▶ Research shows no safe level (ALARA) *

RADON-RELATED DISEASE:

- **LUNG CANCER**

The Respiratory System





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Radon Gas Considerations...

- ▶ Settles in Lower Areas of Structures
- ▶ Affected by Humidity, Barometric Pressure
- ▶ Most People Get Highest Dose at Home (Pennsylvania Nuclear Worker, 1984)
- ▶ Readily Dissolves in Water...Readily Escapes with Agitation

Radon Measurement

- ▶ Can only be Measured Indirectly*
- ▶ Concentrations Can Vary Seasonally, etc.
- ▶ Measured in PicoCuries per Liter = pCi/L
(Curie equals one gram of Radium, "pico" means "trillionth")

Sample Exposure Concentrations

Average Radon Exposure in Air (Expressed in pCi/L)*

Background:	0.4
Indoor Averages:	1.25 to 1.4
Tippecanoe Co., IN:	8.1
Not Uncommon:	5 to 50
Rare:	up to 2,000 (mines)

On Average*...

- ▶ 3% of Single-Family Homes >8 pCi/L
- ▶ 1 in 15 Homes >4 pCi/L
- ▶ 50% of Homes >0.67 pCi/L
- ▶ Basement: 38 million Radon Atoms Undergo Radioactive Decay Daily*

RADON "RULES":

► Federal:

- EPA Recommendation: <4.0 pCi/L (2.0 pCi/L is "Recommend Action Level")
 - Home Target is 0.4 pCi/L (Nat'l. Outdoor Level)
 - Health Advisory: Testing Performed on All Structures Below 3rd Level
- OSHA: Occupational Limit still 100 pCi! (low priority)
- Most OSHA Rules Cover Other Than Naturally-Occurring Radioactive Materials (NORM)
 - Airborne Radioactive Area >25 pCi/L (Rn222), 2.25 pCi/L (Rn220)
 - Signage and Restrictions >7.5 pCi/L (Rn222)
 - Under 18 Years Old: <3 pCi/L

Lifetime Risk of Lung Cancer Per 10,000 Population*

▶ 0.4 pCi/L = 23

8 pCi/L = 450

▶ 2 pCi/L = 120

10 pCi/L = 550

▶ 4 pCi/L = 230

20 pCi/L = 1,100

Do You Have a Radon Problem?

- ▶ All of Utah is in \geq Moderate Risk Area (Carbon, Duchesne, Grand, Piute, Sanpete, Sevier, Uintah = High Risk)
- ▶ Airborne Concentration Depends on:
 - Structure, Design, Ventilation
 - Soil Conditions, Local Geology, Weather
 - Seasonal Variations
 - Water content, disturbance

So We Have a Radon Problem, Now What...?

- ▶ Increase Ventilation to Area
- ▶ Avoid Prolonged Occupancy (Basement)
- ▶ Remediate/Mitigate/Abate:
 - Seal Foundation, Floors, Walls
 - Install Fans, Suction Devices
 - Ventilate to Outside, Preferably Roof (Dispersion)

Sampling for Radon in Air

▶ Short-Term:

- Charcoal Canisters (\$15-30, 2-3 days)
 - ▶ Available at Hardware Stores, Labs
 - ▶ Mail to Lab immediately after Sampling
 - ▶ Side-By-Side Sampling Recommended for cheaper samples

▶ Long-Term:

- Canisters (\$30-50, 3-12 months)
 - ▶ Available by order thru select Labs, Consultants
 - ▶ Mail to Lab after Sampling
 - ▶ Considered More Definitive Result



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Sampling for Radon in Water

- ▶ Grab Sample:
 - Sterile Bottle (\$40-80, immediate)
 - ▶ Available by order thru select Labs
 - ▶ Must be collected with no air in bottle
 - ▶ Sampled at source and throughout process
 - ▶ Mail to Lab after Sampling
 - ▶ Lower Content = Less Reliable Result
 - ▶ Higher Content = More Definitive



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Radon Project Summary

- ▶ Tested Lowest Levels of Buildings and Homes
- ▶ Determined Radon Concentrations/Occupancy
- ▶ Determined Action If Needed
- ▶ Future Considerations:
 - Cost vs. Time Spent in Space
 - Average Concentration in Surrounding Outside Area
 - Efficacy of Remediation Technique (Each Specific and Individual Site can be Unique, but some are predictable)

Radon Project Results

- ▶ No Published Literature Re: Hatchery Exposures
- ▶ Radon Readily Liberates From Water During Disturbance
- ▶ Every Site Has Distinct Results
- ▶ Water Results Very Predictable Once Source Content Is Known; Air Results Predictable Where Water Is Disturbed If Radon is Present
- ▶ Air Results May Vary Building to Building

Project Priorities

- ▶ Residences (more time spent, families)
- ▶ Offices (time spent)
- ▶ Work Areas (time spent)

What about “old” samples?

- ▶ Some samples were obtained from some facilities several years ago.
- ▶ It is likely that OSHA PEL was high enough that nothing was done years ago because the samples did not exceed 100 pCi. OSHA still maintains that exposure limit...
- ▶ Decision: 4 pCi is target limit (EPA rec.)

Results:

► Residences; Mitigation:

► Mantua Asst:	49.5
► Mantua Old:	11.7
► Midway Director	7.8
► Egan Asst.	7.6
► Mantua Director:	5.1
► Springville Manager:	4.1
► Fountain Green Jared' s:	4.0



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Results:

► Residential Long Term Sampling:

- Kamas Ted's 3.6
- Springville Ryan's 3.1

Results: Offices

► Mitigation Studies:

- Mammoth Creek: 31.5
- Glenwood Lab, Office: 26.7, 18.0**
- Whiterocks: 10.7

► Long Term Sampling:

- Midway Locker Rm., Ofc.: 8.4, 7.0
- FES Wet Lab, Virology: 8.0, 7.1
- Mammoth Creek Feed Rm.: 5.6

Other Work Spaces:

► Mitigation Studies:

■ Mammoth Creek Hatchery E:	108.8
■ Mammoth Creek Filtration:	85.0
■ Springville Filtration Control Rm.:	57.7
■ Springville East Hatchery:	41.8
■ Egan Egg Room:	40.3**
■ Springville Filtration:	39.6
■ Glenwood Rearing:	28.0, 26.8
■ Whiterocks Egg Room:	26.6
■ Egan Hatchery:	26.1
■ Whiterocks Main Hatchery:	24.5
■ Glenwood Feed Room:	22.5
■ Fountain Green Warm Water Rearing:	21.9**

Other Work Spaces:

► Long Term Sampling:

- Glenwood Shop, Garage: 12.8
- Midway Rearing, Egg Room: 10.8, 9.5
- Fountain Green Rearing: 6.5
- Mammoth Creek Feed: 5.6

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- ▶ Sample Selected Building (Short-Term)
 - If >3 pCi/L, Sample Long-Term
 - If <3 pCi/L, No Further Action
- ▶ Long-Term Sample Buildings w/ >3 pCi/L
 - If <4 pCi/L, No Further Action
 - If >4 pCi/L:
 - ▶ Ventilate and Re-sample Long-Term
 - ▶ Remediate and Re-sample Long-Term
 - ▶ Restrict Occupancy Time

Draft Utah State Radon Policy

► Occupancy Restrictions:

- The Greater the Concentration, the Shorter the Duration of Work in the Area

- ≥ 4 pCi/L = <8 hours
- ≥ 6 pCi/L = <6 hours
- ≥ 8 pCi/L = <4 hours
- ≥ 16 pCi/L = <2 hours